



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2015

Module Number: EE6205

Module Name: Energy and Environment

[Three Hours]

[Answer all questions, each question carries 14 marks]

- Q1. a) i) Give three reasons as to why electricity has become the most favored form of energy?
- ii) Describe the organizational structure that controls the current energy market in Sri Lanka.
- iii) Explain why Independent Power Producers (IPPs) thermal power plants are being decommissioned in recent years in Sri Lanka?
- iv) Name three such power plants for a) iii).
- v) Comment on how electricity consumption of domestic, commercial and industrial sectors has changed over time in Sri Lanka.

[7 Marks]

- b) Some energy-economy related data for two countries A and B are given in Table Q1. Take 2014 as the base year.
- i) Calculate the income elasticity of demand for both countries in 2015.
- ii) Comment on the energy utilization of A and B in terms of energy intensity values and energy intensity index values.

[4 Marks]

- c) Consider an economy consisting of three sectors: agriculture (A), manufacturing (M), and energy (E). The technology matrix for the three sectors is given below. Use Leontief model to estimate the required production to satisfy a consumer demand of 75 units of agriculture, 50 units of manufacturing and 40 units of energy?

$$\begin{array}{c} \text{A} \quad \text{M} \quad \text{E} \\ \text{A} \begin{bmatrix} 0.15 & 0.22 & 0.24 \\ 0.34 & 0.41 & 0.15 \\ 0.20 & 0.25 & 0.32 \end{bmatrix} \\ \text{M} \\ \text{E} \end{array}$$

[3 Marks]

- Q2. a) i) Why is it important to improve the efficiency of electricity usage in order to handle increasing electricity demand?
ii) Briefly explain two methods which can be used to optimize a lighting system.

[4 Marks]

- b) i) Give four benefits of having a power factor close to unity in a power system?
ii) A 3-phase, 50 Hz, 400 V motor gives an output of 100 hp at a power factor of 0.65 lagging and efficiency of 90%. A bank of capacitors is connected in delta configuration across the supply terminals where each of the capacitance units is built of five 80 V, 2.5 mF capacitors. The total power loss in the capacitor bank is 15 kW.
I. Calculate the new power factor.
II. If the charge per kVA is Rs. 30.00, estimate the power bill saving.

[6 Marks]

- c) i) What are the types of Energy Services Companies (ESCOs)?
ii) Briefly explain the services each type in c) i) provide.
iii) Explain different levels of the energy audit process.

[4 Marks]

- Q3. a) i) Briefly explain how the variable load in a power station increases the generation cost.
ii) A power station has an installed capacity of 110 MW and an annual generation of 74.1 GWh. If the plant remains in operation for 2300 hrs per year, calculate the plant capacity factor and the plant use factor.

[3 Marks]

- b) The annual generation cost of a power station is represented by the formula Rs. $(a + b.kW + c.kWh)$ where the each term has its usual meaning. Find the values of a, b and c for a power station with an annual load factor of 45%, annual demand factor of 80%, connected load of 110 MW and the following cost details. M denotes million.

- Capital cost of building and equipment is Rs 65M
- The annual interest on building and equipment is 12%
- Total fixed cost is Rs 6M
- Scrap value of building and equipment after 30 years is Rs. 5M
- Annual cost of fuel, lubrication oil and repairs is Rs 48M
- Wages of operating staff is Rs 3.5M per annum
- Wages of clerical staff is Rs 2M per annum

Hint: Use straight line method to calculate the annual depreciation charge.

[4 Marks]

- c) i) Write the major pollutants emitted to the environment from thermal power plants and the negative impacts on the environment resulted from each of these pollutants.
ii) Describe how the negative impacts mentioned in c) i), can be minimized by using different filtration mechanisms.

[3 Marks]

- d) i) List the major characteristics of a Retail Model of an energy sector.
ii) A Retail Model is considered as the ideal structure for a power utility. Explain why it is impossible to implement a Retail Model for the Sri Lankan energy sector.
iii) Propose a suitable energy model for the Sri Lankan energy sector and explain how economic efficiency can be maximized through implementing the proposed energy model.

[4 Marks]

- Q4 a) i) Draw a schematic diagram of a diesel power plant.
ii) What are the functions provided by the lubricating system in a diesel power plant?
iii) Why is it essential to heat the lubricating oil before passing it to the filters?

[4 Marks]

- b) i) Draw a block diagram of a gas turbine power plant.
ii) Explain how the thermal efficiency of a gas turbine power plant can be improved.

[4 Marks]

- c) i) State why coal fired thermal power plants are not suitable to supply fluctuating loads.
ii) Explain the differences between condensing type and non-condensing type of steam power plants.
iii) A steam power plant spends Rs. 31.8×10^5 per year for the coal used in the plant. The coal has a calorific value of 5×10^6 calories/kg and costs Rs. 150.00 per ton. If the overall efficiency of the plant is 30%, calculate the average load on the plant.

Hint: 1 ton = 1000 kg, 1 Wh = 860 calories

[6 Marks]

- Q5 a) i) Discuss factors which have to be considered in selecting a site for a hydro-electric power plant.
- ii) Name the common types of prime movers that are employed in hydro-electric power plants and discuss the factors that govern their choice.
- iii) Briefly describe the different dam types in hydro-electric power plants.
- iv) What is the function of the surge tank in a hydro-electric power plant?
- v) With the help of a schematic diagram, explain the operation of pump storage plants.

[7.5 Marks]

- b) A hydro-electric power station is to be operated at a mean head of 205 m and is supplied from a reservoir having a catchment area of 1000 km². The average annual rainfall in that area is 125 cm and 80% from the rainfall is available for power generation. The expected load factor at the plant is 75%. Allowing a head loss of 5 m and assuming efficiency of the turbine and generator to be 90% and 95% respectively, calculate a suitable MW rating for this power station. Comment also on the type of turbine to be installed.

[3.5 Marks]

- c) i) What are the major greenhouse gases?
- ii) What is the importance of greenhouse gases for earth?
- iii) State what is meant by global warming and list the negative impacts of global warming.

[3 Marks]

Table Q1

Year	Country A	Country B
2014	Energy Intensity = 8.5 toe/ LKR million GDP = LKR million 3,200,120	Energy Intensity = 10.2 toe/ LKR million GDP = LKR million 5,400,800
2015	Energy consumption = 2.813×10^7 toe GDP = LKR million 3,400,440	Energy consumption = 6.007×10^7 toe GDP = LKR million 5,500,150